Transparency in Adaptive Mobile User Interfaces

Gaël van Heijst

University of Tampere
School of Information Sciences
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Supervisor: Jani Lylykangas
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User interfaces that enable us to use complicated systems have become omnipresent. Being it through desktop, tablet or mobile devices, a great deal of our interactions with interactive systems is perceived through graphical user interfaces. One of these user interfaces is the adaptive user interface, which adapts according to a user's interactions. This type of interactive system keeps track of a user's actions through a personalized user model. Users can experience great advantages from having personalized user interfaces: imagine different contexts being triggered depending on certain situations, all with great ease of access. Nevertheless, users will perceive these changes differently. In order to communicate these changes in an effective way, certain ways of transparently guiding the user have been proposed.

In this thesis guidelines and principles to facilitate adaptive user interfaces are explored and applied to a novel mobile prototype, hence the title 'adaptive mobile user interfaces'. This resulted in a 'transparent' prototype, which effectively communicated change in the form of prompts and additional options to alter the changes. The second, 'non-transparent' prototype, did not communicate these changes and was not alterable. In order to construct a viable evaluation of the prototype, physiological changes in the form of skin conductance data were tracked in order to measure participants' stress levels. Additional user questionnaires were used to accompany this data. The prototypes were tested by two groups of participants in the form of a 'first usage' and a 'second usage' scenario. The first group perceived the transparent prototype to be highly likeable and effective, but the skin conductance data seemed to contradict this matter. Participants who tested the non-transparent prototype expressed less overall satisfaction towards the this type of prototype, results opposing the outcome of the skin conductance data. Therefore, the hypothesis that the non-transparent prototype would result in more perceived stress as opposed to the transparent prototype was only partially supported.

Key words and terms: User Experience, Electro dermal Activity, Skin Conductance, Adaptive User Interfaces, Mobile Application, Adaptive Mobile User Interfaces, Transparency of Change, Adaptive Support, Prompts.

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1. Introduction

Imagine something familiar as driving a car: people are used to driving their car, they go about their everyday lives not thinking about the mechanics that take place under the hood. The interface of the car (the pedals, steering wheels, buttons and knobs) enable the driver to interact with the car and get them from point A to B. Some interface elements might not meet up the driver's expectations, but the driver gets used to the limitations of the car and masters them. Nevertheless, what if the odd fact occurs that the car changes settings or appearance, based on the driver's behaviour. For instance: if some features of the on-board controls are not used frequently, they get hidden from the dashboard. In some cases, the driver would be left with unwanted adaptations, with no ability to change them. Nevertheless, the ability to partially interfere with these changes is a promising thought that will result in mixed-initiative adaptive systems.

What if the same could happen with user interfaces? What if the system would learn a user's behaviour over time and made changes to the system (and hence user interface) accordingly? This can cause for a more pleasant user experience, if applied properly. Nevertheless, confusion and mistrust can set in if sudden changes are made to the user interface, without being communicated transparently. This is why transparency of change is an important condition for adaptive user interfaces.

A great deal of user interface types already exists. An overarching group of user interfaces can be found in the classic graphical user interface domain (GUI) with the WIMP model of windows, icons, menus and pointer as developed at Xerox PARC in 1973. No longer were computer actions seen as abstract lines of code, but communicated with interactive elements that listened to specific actions, with evenly specific output.

The first subdivision being the direct manipulation interface as described by Norman [1982] when he introduced a desktop metaphor to the interface landscape; being one of the first graphical user interface representing real-time objects that could be manipulated. One great advantage of the direct manipulation interface concerned a greater deal of overview of the content and a constant presentation of the objects that could be manipulated.

A second type was developed by Schneiderman [1982], as he saw a need for a more personalized user interface in the form of adaptive user interfaces. At first, this idea was criticised, when researchers were indifferent to whether this novel user interface principle would ever be seen as a standard approach to user interface design. With the rise of the graphical user interface and more advanced algorithms to support a learning interface system, the body of research grew. Accompanied by this, more answers come in the form of three factors [Robinson et al., 2015]: the rise of processers' speed, the growing field of competitors on the mobile market and the undeniable impact the first iPhone had on the field of mobile devices. These three factors are making way for future areas of adaptive (mobile) user interfaces [Robinson et al., 2015].

A third type of user interfaces is seen in the adaptable user interface, in which the users themselves can make changes to the system or application. Imagine changing the settings to any application or system setting people might use on a mobile device, to fit a more specific need.

Due to the possibilities of both adaptable and adaptive user interfaces, some researchers opt for a '*best of both worlds*'-solution in the form of mixed initiative user interfaces; something which this thesis will greatly focus on. Höök [2000] claims that the future of the adaptive user interface lies in this type of user interface, supported by the opportunity for users to 'peek' at the underlying mechanisms that cause adaptations of the system.

Applying a more personalized touch to a mobile phone is a complicated issue, in which work by researchers, mobile device manufacturers and application designers altogether play an important role. In order to provide a suiting user experience for every user, the system has to be able to collect and reflect on the behaviour of the user. But, in order to do so effectively, the interactive system needs to figure out the preferences of the user. This information is stored in the system's user model. All of this information makes for a better basis to develop systems that are able to learn and communicate changes and new presentations of the interactive system.

Communicating the changes in an adaptive user interface is called 'transparency of change'. Kühme [1993] described an 'inspectable' system to be the solution to communicate changes applied to the user interface. This came in the form of a desktop application that recognized certain task- and tool combinations and prompted these together in modal menus, making tasks highly contextual.

Transparency of change in a desktop interface is one thing, but the same principles can be applied to mobile applications as well. With the rise of 'smart applications' and omnipresent mobile devices we carry with us all the time, technology can track and read a user's actions under any condition. Adaptive mobile user interfaces have been suggested based on certain tasks, the user's behaviour or the current environment (e.g. weather, time and location).

When evaluating adaptive user interface for desktop applications, assumptions can be made that these principles can be applied to mobile user interfaces as well. Transparency of change has potential on mobile devices since the context dependency of applications combined with the limited screen real-estate.

Therefore, this thesis focuses on user initiated changes made to a novel mobile application specifically designed for this thesis, called Adapt. In this group-work application the user is able to make groups based on shared topics, plan meeting with its members and post information to a feed. Key is to communicate changes made to the user interface with the right amount of transparency. Throughout the usage of the application, the user model of the application gathers information that will change the appearance of the application. Gathering this actual information would shift the focus of this thesis to a more technical oriented work. Therefore, a constructed scenario was designed in which the user was asked to perform a list of certain tasks.

During the actual testing phase, a first and second usage of the application was staged. All participants were given the first usage application to familiarise with the application and provide initial information for the user model. During the second usage however, both groups were given a different prototype. The transparent prototype (B) has a high level of transparency, and communicates a lot of changes to the users together with the possibility to alter changes. The opposing non-transparent prototype (C) does not communicate these changes based on the user's first behaviour and has no options to alter changes.

In order to measure perceived differences between both prototype B and C, a physiological parameter is introduced. Paas [2003] and Khawaji [2015] for instance suggest that measuring electrodermal activity has been proven to be an accurate parameter to measure user-satisfaction in testing scenarios. These tests were conducted in the ESC-lab at the TAUCHI Research Centre (Tampere Unit for Computer-Human Interaction) at the University of Tampere. During these tests, the user's skin-conductance levels were measured since form of physiological measurement is proven to be trustworthy to measure this type user reaction. Furthermore, pre- and post questionnaires were conducted to compliment the skin-conductance data.

This thesis entails six chapters. Chapter 2 provides background information on electrodermal activity, user models and different types of user interfaces. Transparency of change and adaptive support are presented here as well. Furthermore, the link between adaptive user interfaces and mobile design is made. This leads to a presentation of the pilot-study case: Adapt, which holds a first-usage (A) and second usage scenario (B or C). Chapter 3 mentions the Methods that are used in the experiment and thoroughly describes the prototypes and their functionalities. Chapter 4 presents the results of the user tests. From which in chapter 5 the discussion is formed. Chapter 6 leans into possible future implementations and limitations of this study. Full examples of the user test, user questionnaires and the prototype can be found in the Appendix after chapter 6.

2. Background and Literature Review

The following chapter aims to provide background information concerning all key principles and concepts in this research. First of all, different types of user interfaces are explained, concluding with the mixed-initiative user interface. Opportunities for this type of interface, as well as its concerns are elaborated on. Afterwards the concept of adaptive mobile user interfaces is explored including how principles from mixed-initiative user interfaces can be applied to mobile user interfaces. Hereafter, the use of a physiological factor, namely skin conductance level, to track user responses is explained. This chapter is concluded with the hypothesis and research questions.

2.1. User models

In order to construct a cohesive image of four types of interfaces (proceeding in subchapter 2.2), the user model needs to be explained. In order for an adaptive system to be truly adaptive and/or adaptable, it needs personal data. This data is collected in a user model. A user model, as described by Benyon [1993] is "the representation of the user maintained by the system." Langley [1999], described a user model and its relation to adaptive interfaces in the following way: "An adaptive user interface is a software artefact that improves its ability to interact with a user by constructing a user model based on partial experience with that user". The system needs information from a partial relation with the user, in order to make changes based on a user's input. Fischer [2000] describes four types of user models:

1) *Static user model*: is seen in an interactive system in which the user can not alter information of the system;
2) *Dynamic user model*: is seen in an interactive system where users have the ability to learn from the interactions they engage in (for instance, giving a 'Like' on a Facebook page);
3) *Stereotype based user model*: is seen in an interactive system that derives information from demographic statistics;
4) *Highly adaptive user model*: is seen in an interactive system that represent one specific user and is customised to his or her own needs. Fischer calls this last model very promising. In order to be so, it has to collect a lot of information prior to proper adaptation.

Alvarez-Cortes and Zarate-Silva [2007] describe a lack of focus in the first three types of user models. They address research communities to focus more on individual needs of users. They state that both user model and adaptive user interface are two promising perspectives. Adaptation takes place based on the user model, which will result in an adaptation effect (changes in user interface). Alvarez-Cortes and Zarate-Silva [2007] explained that the purpose of a user model is to display tailored data content at the user interface level. Changes are monitored within an application model [Kühme, 1993] and communicate this data to the user model, from where adaptation takes place. This process is seen in figure 1. Within this process, two sub-divisions of data-gathering exist:

- **Implicit**: this type of data gathering holds the actual actions a user performed within the system (e.g. saving cookies or browser history). It is also called an *automated* user model technique, of which no direct feedback is provided to the user;
- **Explicit**: this type of data gathering will help make changes over time. It is also called an *informed* user model technique. This technique is more complicated and has to be able to recognise patterns of the user's behaviour.

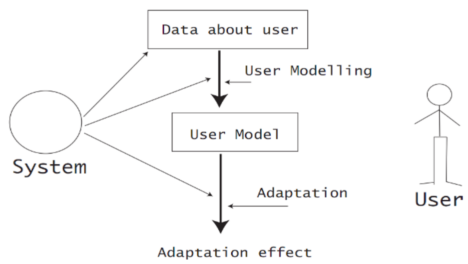


Figure 1. The user- and system model [Kühme, 1993].

2.2. Types of interfaces

An interface in general can be described as "*all components of an interactive system (software or hardware) that provide information and controls for the user to accomplish specific tasks with the interactive system*.", as defined by the ISO (International Standards Organization) in 9241-110 [2006]. Researchers and HCI-practitioners describe different types of interfaces. Four distinctions can be made: direct manipulation, adaptable, adaptive and mixed initiative (described in 2.2.1 to 2.2.4). The following subchapter will describe all four of the different user interface types.

2.2.1. Direct manipulation interfaces and beyond

User interfaces help to understand and control the complex systems behind them. They offer a visual representation to otherwise difficult systems. Schneiderman [1982] stated that a direct-manipulation interface is a continuous presentation of the object in which interactive elements are in place instead of syntax or line-based code-interfaces. Most importantly, the impact of the changes should be directly visible in the graphical presentation of the user interface.

Following this statement, Norman et al. [1985] adopted the term in '*Direct Manipulation Interfaces*'. They concluded that direct manipulation interfaces have their successes and flaws. One of the successes being the direct feedback of actions. Another being, the direct representation of objects and actions users are already familiar with (e.g. buttons in real-life can be pushed on screens as well). Norman emphasises the fact that in order to move forward in the domain of user interface design and technology in general, designers should not restrict themselves to crafting interfaces that are capable of doing things we can already do, instead they should focus on moving forward. Therefore, the next paragraphs (2.2.2 to 2.2.4) focus on interfaces that are more flexible by nature.

2.2.2. Adaptable user interfaces

An adaptable interface lets the user take control of the change. Multiple researchers focused on the adaptability of menu items in desktop applications [Findlater and McGrenere, 2014]. Adaptable user interfaces are classified under dynamic interfaces. In research conducted by Sears and Schneiderman [1994] users were able to determine their favourable order of list-items in a menu design.

Results by Findlater et al. [2014] showed that users preferred customisability over static menu design. Apart from this satisfaction, participants were not completely pleased with system-initiated changes, this proved to be a point of distrust and slight frustration.

Other examples such as the adaptive hypertext navigation [Kaplan et al., 1993] and the study of an adaptive learning environment by Brusilovsky [1994] are examples in which benefits of adaptivity versus adaptiveness are evaluated. In essence, adaptable user interfaces are situated around user control and adaptive user interfaces around system-situation control.

2.2.3. Adaptive user interfaces

The second type of interface is the adaptive user interface (system), in which the system initiates its own changes, based on the users' interactions with the system. These changes, as mentioned by Benyon [1988], can be made based on three main orientations:

1) Task-oriented;
2) User-oriented;
3) Environment-oriented.

Alvarez-Cortes and Zarate-Silva [2007] showed interest in these three factors, and claim that these are still applicable to mobile application usage, hence the interest for this topic in this thesis. User-initiated changes have been of high interest when Innocent [1982] first pointed out the term in in his paper '*Towards self-adaptive interface systems*'. Interestingly, in the same year as Norman [1985], Greenberg and Witten [1985] published an article called '*Adaptive personalised interfaces - a question of viability*' in which a feasible example of adaptive user interface design was presented.

One example of an adaptive user interface can be seen in van Tonder and Wesson's [2008] study in which they used a model originally adopted for mobile cartographic system developed by Reichenbacher [2004]. Reichenbacher defined four categories on which user interfaces can change their presentation:

1) Content presented in the user interface;
2) Layout of the elements in user interface;
3) Visualisation of the user interface; and
4) Technology used to construct the user interface.

Based on these subdivisions, van Tonder and Wesson [2008] developed a mobile application that allowed users to geotag pictures and videos they made in order to achieve a more natural way of scrolling through photos on a mobile device. Another example can be found in the Newsweeder application by Lang [1995] that suggests news articles based on a user's prior search history.

From the lessons learned from studies like the study by Findlater et al. [2004], and concerns mentioned by Höök [2000] the conclusions can be drawn that users prefer more control over an adaptable interface, but on the other hand users are still steps away from giving total control to a system. In the following subsection a mixed-initiative user interface portrayed by Bunt et al. [2004] is presented to be a suitable solution. In this solution issues as predictability and accuracy are tackled to provide a more accustomed user experience.

2.2.4. Mixed Initiative interfaces

The third type of interface is a mixed-initiative interface. As mentioned earlier, users tend to feel uncomfortable with sudden undefined changes to the user interface. Bunt et al. [2004] support the need for adaptive support in a mixed-initiative interface, where focus lies on guiding and supporting the user through the adaptations: user-initiated and system-suggested. They propose the importance of helping users by supporting them in the process of adaptation as early as possible. When users come to face the adaptations in the user interface, they should get insights into discarded and changed content.

Höök [2000] mentions the importance of comparing a non-adaptive user interface versus an adaptive user interface. Hence this will make all the difference for future research. She promotes the idea of having an interface which is 'split' into two pieces, one piece that is designed to be predictable and editable, and another part that works outside of the user's sight. She uses a glass box metaphor to explain the idea of an intelligent interface system working on these two system levels. Users can 'peek' into the intelligent system in order to understand its dynamics in order to alter the 'outer box' (if considered necessary) to a certain degree. The more complex mechanics of the system are visible to the user, but not editable (hence the term glass box). The ability to get insight into these changes is one solution to the sense of powerlessness that users experience. This thesis will focus on task and user-oriented factors (also called user-initiated) and the possibility to give insight into changes and properly guiding the user throughout the process of adaptation. The following subchapter will focus on ways to provide these insights, hence taking back the control over adaptive user interfaces.

2.3. Taking back the control over adaptive user interfaces

Researchers mention possible directions the work on adaptive user interfaces can proceed. One direction entails a fully adaptive user interface with highly adaptive user models in place. Other research points out towards more promises. This twofold is displayed in the following subchapter. Furthermore, the need for more control in the form of transparency of change is considered.

2.3.1. Solutions for adaptive systems

Höök [2000] described two concerns with fully adaptive systems. The first one being that a system equipped with human characteristics will induce higher expectations for users, since they will rely a lot on the systems' intelligence. Something which the system can not always live up to. Secondly, Höök [2000] proposes the idea that designers and researchers should simply use the computer for what it is good at, notably to handle and process large amounts of data and present them in a meaningful way. She identifies this as a call to take back control over adaptive user interfaces and its user models. Furthermore, she suggests a couple of ways to do so:

- Split the interface into one predictable and stable part, and another that will learn and adapt [Kozierok and Maes, 1993];
- Give users an opportunity to look at the user model, with a possibility to alter it [Kay, 1994], one other of these inspectable systems being the '*adaptive prompt system*' by Kühme et al. [1993];
- Take into account the time it takes for a user to be comfortable with the changes, and time to sort out changes in the adaptive prompt [Kühme, 1994].

Possible challenges designers of interactive systems can face when designing adaptive user interfaces are mentioned by Alvarez-Cortes and Zarate-Silva [2007]. They differentiate four points on which adaptive user interface can focus in order to outperform regular direct-manipulation interfaces:

1) Creating personalised systems,
2) Taking over the task from the user,
3) Reducing information overflow,
4) Supporting users when encountered with novel systems.

Alvarez-Cortes and Zarate-Silva [2007] also pointed toward two possible ways of prolonging the research efforts in adaptive user interfaces, being:

1) The first research plan starts from the fact that, with adaptation, comes also loss of understanding. A further line of work would be to determine conditions under which adaptation can have positive and negative effects.
2) The second plan concerns the effects of interruptions in user interface adaptations, in order to provide proper advice.

In order for users to adapt their user model to the new interface changes, a certain amount of trust has to be conveyed by the interface, as described by Höök [1996]. This trust can be achieved if a user is aware of the changes that are initiated by the system and if he has a certain amount of control in this process. Having these principles in place will ensure greater overall pleasure and understanding of adaptive user interfaces.

Previous studies on adaptive user interface design have focussed on task completion time [Gajos, 2008; Bunt *et al.* 2004]. However, to my further knowledge there is a gap in current research, which is whether or not the user is satisfied with the adaptations and possibilities to alter changes. In order to ensure proper control over the user interface, transparency of change is of importance. The following paragraph will elaborate on these two features.

2.3.2. Control and transparency

Users are used to the fact that they are transparently guided through a regular (direct manipulation) interface. One example is as simple as a changing colour of a visited link from blue to purple (indicating a previously clicked link). A feeling of total control is practically non-existing in a fully adaptive user interface application. Höök [2000] proposed that when applying adaptive user interfaces principles to a system, five factors are affected by it: 1) lack of control, 2) predictability, 3) transparency, 4) privacy and 5) trust. The focus in this thesis is not towards privacy and trust, therefore transparency of change in the interface will be a key issue (which will grant more predictability and control for the user).

Adaptation of the user interface can have a negative effect on a user's experience, as Shneiderman [1987], for example, already referred to by using the basic principle of 'predictability' of the user interface. Höök [1996] inevitably concluded that in order to design adaptive user interfaces, designers of interactive systems should purposely break some basic user interface design principles. Tomlinson et al. [2007] mentioned two main concerns with adaptive changes as well: 1) the user-interface adapts when the user does not want to, and 2) it is unclear to the user how the user interface has changed. This problem called for more 'transparency'.

Oviatt [2006] introduced a solution called '*dynamic support*' and mentioned eight principles to do so. From those principles, three are most applicable to this research:

1) Transparently guide the user;

2) Minimise cognitive load, and;

3) Minimise interruptions.

These changes were also called *implicit* as mentioned by Alvarez-Cortes and Zarate-Silva [2007]. Höök's glass box describes the moment when a user can inspect the system's dynamics and gets notified of the changes in the user interface (also called 'explicit' change, by Alvarez-Cortes and Zarate-Silva [2007]). These changes can be communicated for instance by using form and colour: making adaptive parts of the interface highlighted in order for the user to effectively depict change. Other studies by Tsandilas and Schraefel [2005] have also shown the effective usage of highlighting changing elements as an effective way of communicating user interface changes.

2.3.3. Adaptive support and prompting

Kühme et al. [1993] suggested adaptive prompting as a form of suggestive information to help users make decisions about the interface's behaviour. Adaptive prompting aims to guide users in an interactive environment. Users are invited to inspect the adaptive prompt and control the adaptations if wishing to do so. This is also called computer-aided adaptation [Kühme et al. 1992]. Cook and Kay [1994] describe the same phenomena and coined it 'altering the user model'. They propose that a user should be allowed to inspect and alter the user model in order to make more sense out of it. The study of Kühme et al. [1994] focused on hierarchies of menus and dialogs but is still applicable to this day. It suggests the use of direct prompts for the frequently used actions in a particular situation. Adaptations take place based on a user's interactions and constantly evolving needs and wants. In this case, the user model is used to execute actions based on a user's knowledge or usage in the form of e.g. preferences (for tools, settings); an overall experience (derived from how many and how tools are known), and; a user's preference for performance of guidance prompting (overall user experience). Kühme [1994] also suggests two alternative ways to bring attention to frequently used actions:

1) Present frequently used actions in a separate pre-selection (which he calls the *tool prompter* and *action prompter*);

2) The system could communicate changes of items within the non-adaptive interface (with adaptive prompting in the form of *dialogue boxes*).

Both of these actions are seen strictly as complimentary actions, not to be presented as a substitute for the original interface. These forms of prompters can be in place to aid to the process of transparently guiding the user through adaptations of the user interface.

Adaptive tool prompter: Figure 2 forms an example of an adaptive tool prompter of a desktop application concerning:

- **tools**: all available tools in the user interface;
- **files**: all available files in the user interface;

- **relationships** between tools and files: for instance, prompting that tool X and Y can be used for A and B task;
- **tasks** context: a set of tools used together to work on a specific task or group of tasks;
- **projects**: a set of files related to a project in the application domain;

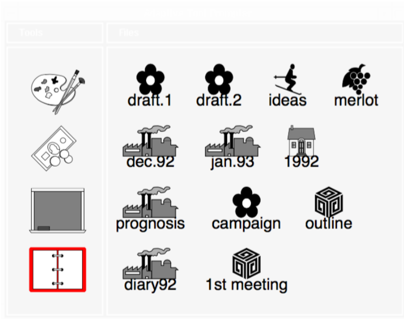


Figure 2. Adaptive tool prompter [adapted from Kühme, 1993]

Adaptive action prompter: Instead of having tools and files, the adaptive action prompter consists of object classes, instances, actions and conditions.

Object classes	**Instances**	**Actions**	**Pre- and post conditions**
Class that guides users about the actions that work at that particular moment;	One particular situation;	Actions that can be performed with the tool (e.g. save, copy, etc.);	Conditions in which an action is executable;

Table 1. adaptive action prompter components [adapted from Kühme, 1993]

In order for the tool- and action prompter to come into place, the following steps would be taken if a user uses an application with adaptive prompting support:

1) Run-time of the application,
2) User performs actions,
3) Application model monitors a user's actions (through contexts of use),
    a. Application model has three contexts;
        i. **Object** context: which objects are in a user's current focus (e.g. selected objects, input focus, keyboard actions, etc.);
        ii. **Action** context: gives pre- and post conditions of actions (explains when and why a certain task can be done with certain tools);

iii. **Task** context: activated when tools that are normally active in that context are activated (the conditions of a task);

4) Information is send to the user model in order to remodel the application,
5) New user model is constructed,
6) Above cycle repeats.

These prompts should inform users on what they are able to do with the elements in the interface. Kühme [1993] illustrates this method as a menu that is constantly visible to the user, in order to provide guidance throughout the application. Its content will be adjusted with every context change based on the user model or application model.

These actions can be called *shortcuts*. Nevertheless, Kühme [1993] challenges the idea of shortcuts, by labelling it to be even more harder in time for the user to remember abstract meaning from them. This said, Kühme et al. [1992] proposed that this technique will act as intuitive guidance in the form of proper objects and actions presented at any time. He argues the usage of adaptive prompting support in pen-based systems due to the smaller screens. This suggests another implementation (one that Kühme [1992] was unaware of) being that of adaptive prompting support in mobile user interfaces (as in pen-based systems, mobile device also have a restricted screen size).

Bunt and Conati [2004] also coin the term 'adaptive support' as a means to guide the user through change. They define the communication of change into two categories '*Up Front*' and '*As you Go*', differentiating between making changes to the system before a user interacts with certain functionalities, or let the system take care of the changes. Other studies on adaptive support have been conducted by Malinowski [1993] and also suggest changing colours and highlights as proper signals to indicate change.

Höök [1996] pointed out a concern with prompting, being the fact that users have to get accustomed to the use of these program-specific terms such as 'goal', 'action' and 'interaction' as mentioned earlier by Kühme [1993]. Careful conclusions can be made about this subchapter, being that adaptive prompting added to an adaptive user interface results in a mixed-initiative user interface design. A system in which pieces of adaptable and adaptive user interface principles are mixed in order to craft a better user model and hence more understanding with the user. In essence it is important to provide appropriate feedback to the user in order to communicate change. That is where promising areas of research are at the moment.

2.3.4. Future areas for adaptive user interface

Research done by Häkkilä and Mäntyjärvi [2006] mentions ten guidelines on context-aware mobile systems, which will be of focus in the next chapter. Next to that, they defined seven possible challenging areas in the process of adaptation, ranked chronologically, being:

1) Selecting appropriate information sources,
2) Uncertainties in information sources,
3) Successful inferring logic,
4) Successful execution of appropriate actions,
5) Informing the user of these actions,
6) Ensuring user control,
7) Learning and adaptation for future usage.

From this study, mainly points 5 and 6 are of interest and show the need to apply these to the prototype in this body of work.

2.4. Adaptive mobile user interfaces

Previous research, as mentioned earlier, was based on desktop user interfaces. Nevertheless, with the omnipresence of mobile devices, this field of adaptive mobile user interfaces is more than promising for mobile user interfaces as well, hence the term adaptive mobile user interfaces. The reasons for implementing these principles to mobile user interfaces are described in the following subchapter.

2.4.1. Why mobile?

Adaptive mobile user interfaces shape the way for more personalised interfaces for users. Mobile devices have already become ubiquitous, and the amount of devices is growing. Ubiquity leads to contextual usage, hence the need for adaptive systems. The implications of mobile device usage can be divided into five plausible areas: context, focus, speed, screen size and accessibility.

Context: the usage of mobile devices is highly contextual. Users carry their device(s) with them throughout the day and check for changes/updates repeatedly under different circumstances. While browsing through a list of restaurants or shops on a mobile device for instance, some list- and menu items might change as well according to the user's location. In the study by van Tonder and Wesson [2008], the adaptation of the menu of the mobile device application took place when the user changed location. Users applauded solutions based on automatic menu customisation. In a sense, the user interface presented contextual information to the users, related to their current geolocation. Van Tonder and Wesson [2008] point out the importance of adaptive visualisation systems focussing on user satisfaction. As pointed out earlier, little research has been conducted concerning this topic. In a similar study by Fukazawa et al. [2009], dynamic change of the mobile menu was initiated based on the user's operation history.

Focus: in essence, a mobile application focusses on one specific task. Williams [2014] concluded the existence of four types of contextual data on which a mobile user interfaces can change: time, location, activity and emotion. Her research focusses on the order in which users use mobile applications and making the user model learn from that pattern, in order for it to rearrange applications according to the user's specific focus and context. Williams proposes the idea of *topic modelling,* in which the mobile device recognises certain 'topics' and learns from these situations (for instance checking email in the morning, and thus presenting the email application on wake-up time). Same solutions are mentioned by Bridle and McCreath [2006], which will be explained in 'Accessibility'.

Speed: Findlater and McGrenere [2008] stated that a mobile menu of high accuracy was a lot faster and more beneficial to the user than static menus on mobile applications. They tested a menu design in a adaptive mobile user interface that ranked items in the same order as users selected them. The ones that stayed untouched were hidden over time. Users showed a good response to having more control over ordering functions. What they did conclude was, in order for them to explore functionalities, they had to go look for the features that were hidden. In other words, exploration of functions is diminished. This study showed that users were more likely to accept adaptive interfaces on smaller screen sizes. Findlater and McGrenere [2008] like to press on the fact of mobile adaptivity and propose mobile adaptive user interface as an area of future interest. Taking away a possibility to explore the interface, is a point of critique for many adaptive user interface systems.

Screen size: Throughout research in human-technology interaction it has shown that adaptive user interfaces seemed most promising for mobile interfaces. Due to a variety of features and limited screen size this can only cause for a limited amount of visibility of certain elements in the user interface. Findlater et al. [2008] conclude that with reduced screen sizes, comes the negative effect of having items or content get lost in hidden menus and the like. Therefore they conclude that using adaptive user interface principles on mobile application will be of great aid for users to get contextual information.

Accessibility: In the study performed by Bridle and McCreath [2006], an interesting case-study was presented in which a user's mobile application usage was tracked and used to make it more easy to reach shortcuts on the 'home screen' of the mobile device. Thus creating an adaptive shortcut home screen for easier accessibility.

2.5. Adaptive mobile user interface design guidelines

In this subchapter a series of guidelines will be derived from studies on adaptive user interface design conducted on desktop as well as mobile devices. The point of these principles would be to act as guidelines for a future prototype.

Because of the support of adaptive user interfaces and mixed-initiative user interfaces (as part of adaptive user interfaces) it can be seen as future work to incorporate adaptive principles in mobile user interface design as well.

Earlier research done by Häkkilä and Mäntyjärvi [2006] focussed on context-aware mobile computing. Although this research describes the use of contextual data gathered from sensors activity in the mobile device to initiate change, the principles are still applicable to this thesis' focus on user-initiated activity. They stated that user interface designers are often unaware of system specifics that can be used to communicate change in the user interface, thus limiting the ability for a more tailored user experience. Hence, the following set of ten guidelines was concluded in order for designers to develop adaptive mobile user interfaces.

GL1: Consider the uncertainty in decision-making situations. Häkkilä and Mäntyjärvi [2006] claim that the designer should be aware whether or not to notify the user of changes that are being executed. **Best practices**: ask the user for conformation before executing actions, show system actions beforehand and after. This principle is found in Kühme's 'pre- and post condition' guideline in his adaptive prompts' research.

GL2: Prevention from interruptions: the system should make some sort of priority order of actions that are used by the user. However, in order to communicate this effectively the user should not perceive this as 'spam' or irrelevant information. A possible solution to this is the option to filter information. **Best practices**: the adaptive prompt menu can be accessed in any circumstance, but can be hidden just as easily.

GL3: Personalisation: the system should be able to filter information according to the user's preferences. This categorisation should be meaningful and intuitive. Kühme proposed a design in which the system will adopt certain scenarios and actions over time. **Best practices**: Frequently used actions will be placed in one prompt (for instance, menu-items arranged according to usage). If items are unused or infrequently used, they can be hidden.

GL4: Avoid information overflow: it has been shown that users dislike to be presented with too much information at once. Some users experienced trouble from seeing push-notifications. **Best practices**: using different states of the adaptive toolbar, by presenting contextual information to the user. This can be done by using the 'action toolbar' and 'task toolbar' principles.

GL5: Secure the user's privacy: prompts can be too visible for users, meaning they feel that their privacy is invaded. One example showed that users were confronted with unwanted sounds, and tactile feedback. **Best practices**: One point that is mentioned by Häkkilä and Mäntyjärvi is that users should be in control of audible notifications that can make them feel insecure when in social scenarios (for instance, a mobile phone alarm goes off in a public place and a user is unaware of how to turn this alarm off).

GL6: Remember mobility: the use of adaptive user interfaces is highly contextual in research by Häkkilä and Mäntyjärvi. It showed users that are on the move. The users ask for fast navigation to their locations of choice. This is a promising terrain for adaptive mobile user interfaces. But, in this thesis is focussed on user-initiated change, this sixth guideline can still be used as a means to express a limited screen real-estate inherent to mobile devices. **Best practices**: the prototype will take into account limited screen real-estate and the fact that users are only able of accessing a limited amount of resources on their mobile device.

GL7: Secure the user control: the user should feel in control in all circumstances. One possible solution might be to provide an option to switch between filtered/non-filtered view. The automation level should be controllable by the user to a certain degree. **Best practices**: The prototype should have the option to re-order the items as they were in another state.

GL8: Access to context: default states of attributes and their measures might be counter-intuitive or confusing for users. The users should be able to rename locations of certain elements for instance. **Best practices**: titles and labels of items in the prototype can be changed according to the user's needs.

GL9: Visibility of system status: the system should provide the user feedback and an ability to check the history of usage. This guideline relates strongly to GL1. **Best practices**: the prototype should show relationships between tools and files. These preferable changes can be saved in the adaptive prompt toolbar. Visual communicators such as changing colours or layouts can be used to communicate change.

GL10: Usefulness: this guideline concerns the actual functions. If the functions are perceived to be useful they should be kept in the application. Whether this is positive or negative should be stored for future occasions. This is part of what Kühme calls *proactive* and *reactive* use. **Best practices**: the prototype will have to keep a log/history of a user's action (per group, or in the application as a whole) and show these actions in the form of 'History', as with Internet browsing history for instance. The user should be able to keep or discard changes that are made. The guidelines and prototype outcomes can be applied to novel mobile interface design principles.

In order to properly validate these design principles and guidelines, some objective and subjective data needs to be collected from the user. Therefore, the following section will explain how user experience research can be conducted with the focus on usability tests and questionnaires and skin conductance tests.

2.6. Conducting user experience research

User experience can be seen as "*a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service*." as defined by the ISO in ISO-9241-210 [2010]. Certain tools are developed in order to track and evaluate these perceptions and responses. Prototypes itself being a valuable second user experience research tool as defined by the ISO in ISO-9241-210 [2010]. The fact that early prototypes are highly editable makes them an ideal tool to test preliminary user interface principles with. Skin conductance is introduced as a subjective data measurement to accompany the usability tests and user questionnaires.

2.6.1. Subjective data: usability tests and questionnaires

In order to collect subjective data from the user's experience with the prototype, a user questionnaire such as the User Experience Questionnaire (UEQ) by Schrepp et al. [2009] or Self-Assessment Manikin (SAM) by Lang et al. [1980] can be used. In this thesis a section of the UEQ is used to construct an overview of a participants' feelings towards the prototype during both scenario of usage.

2.6.2. Objective data: An introduction to skin conductance

In order to measure the level of satisfaction of an interactive product, research has shown benefits of measuring a user's physiological responses to stimuli [Sano and Picard, 2013]. Physiological responses (or signals) are for instance: blood pressure, heart rate, heart variability, skin conductance, cortisol levels and pupil diameter measuring. In human-technology interaction research these measurements have been used to determine the amount of cognitive load [Leyman et al., 2004; Wilson, 2009 and Engstrom et al., 2005]. One of them being skin conductance level studies, in which changes in measurement of sweat-levels on the inside of the hands and/or feet can indicate changes in the sympathetic nervous system (SNS). The SNS being responsible to trigger a 'fight-or-flight' reaction as a results of immediate stress. When measuring these levels, small currents are passed through electrodes on the fingers.

There are two reasons why skin conductance is a viable research method. First, measuring skin conductance levels has been proven to be one of the most reliable methods of measuring a person's arousal levels [Bouscein, 1992], due to the fact that the measurement is less likely to be manipulated. As Ayzenberg [2012] concluded, the skin is the only organ that is exclusively connected with the sympathetic nervous system. Secondly, this technique is one of the most cost-efficient techniques. As early as 1879 Vigouroux and Fere came to the conclusion that measuring skin conductance said something about a person's emotional response [Neumann, 1970]. Valence and arousal are the most important parameters while using this technique. Valence can be seen as whether something is perceived as positive or negative and arousal as a measurement to determine how calming or exciting the experience is perceived.

Electrodermal activity and skin conductance levels hold different terms which are explained in table 2 derive from research done by Dawson et al. (2001).

Measure	Definition
Skin conductance level (SCL)	Tonic level of electrical conductivity of the skin
Skin conductance response (SCR)	Phasic change in electrical conductivity of skin
Non-specific SCR (NS-SCRs)	SCRs that occur in the absence of an identifiable eliciting stimuli
Frequency of NS-SCRs)	Rate of NS-SCRs that occur in the absence of identifiable stimuli over time
Event-related SCR (ER-SCR)	SCRs that can be attributed to a specific eliciting stimuli

Table 2. Basic definitions for electrodermal components (adapted from Dawson et al, 2001).

Skin conductance levels (SCL) can be filed under electrodermal activity (EDA). EDA is measured using microsiemens units (μS). EDA can be used as a form of physiological response to measure a user's response to interactive products experiments [Braithwaite et al., 2015]. Siddle [1983] suggested that skin conductance response shows cognitive changes as well as emotional response to stimuli. SCR levels are of importance in any study, since they are the sudden 'outbursts' or short-term events, the phasic states. Whereas tonic levels represent a more stable pulse of EDA, but can also slowly vary over time. Tonic being slow changes and DC and SCL (Skin conductance levels). Phasic being non-specific SCRs (NS-SCRs) and event-related SCRs (ER-SCRs). The tonic changes will be a constant factor during measurements, whereas the phasic ER-SCR's will show peaks in the data, and can be linked to specific events.

2.6.2.1.Examples of cases using skin conductance levels

In research done by Hernandez et al. [2014], the researchers measured stress levels in call-centre employees using SC-levels. Sudden outbursts of SC-levels measured through the sweat glands in the palm of the hands, indicated stressful situations. In another case-study Sano and Picard [2013] conducted a study in which the participants' stress level was tracked using a mobile device sensor. Again, strong increases in stress levels indicated the burden of responding to text-messages while on the go.

As mentioned earlier Ayzenberg et al. [2012] conducted a research with a mobile sensor system meant to record response to social interactions of users called FEEL. In this case-study, the user is equipped with a special mobile application and a wrist device that recorded the EDR signals. The FEEL system kept track of a user's most stressful days to provide insights in daily habits. In addition to the data collected from the SCRs, participants were asked to fill in a small post-test questionnaire with a 7-point Likert scale. This study focussed on tracking emotions based on interaction with mobile devices.

In a recent study by Nourbakhsh et al. [2015] participants were asked to perform 8 arithmetic reading tasks (four slides with words) with 4 difficulty levels. Whereas each participant did two rounds of tests on each difficulty level in a random order. They were asked to click on three, four and five letter words while SCR levels were measured. Results were measured using SCR data and it showed that SCR data is valuable data when researching cognitive load.

2.6.2.2.Interpreting skin conductance levels

In order to interpret skin conductance levels, a baseline SC-level is needed, being the average tonic level of an individual. There are several techniques to achieve this. Preferably the participants are kept in a relaxed state for 15 minutes, in which the body acclimatises to the inside temperature of the room and the stimuli around them. Alternatively, for computer-related experiments, Braithwaite et al. [2015] suggested a 2- to 4-minute baseline session. From this session, the frequency of NS-SCR (EDA responsiveness in a tonic state), an average amplitude of NS-SCRs, and the SCL can be derived. On the other hand, Nakasone [2005] was also aware of a 'baseline problem' when conducting skin conductance level research. He adopts Levenson's theory [1988] to strengthen this statement. Nakasone states that an obvious choice for a baseline study is in a 'rest'-situation, where the user claims to have no specific emotion. It should be noted that being in a lab-environment with the notion of being part of a study, can elicit a certain amount of minor stress. Nakasone therefore suggests a three minute (calming) music listening session. This is done in order to generate a moderate level of autonomic nervous system activity. This technique will be used as part of a method to achieve a baseline SC-level. With this a physiological factor is introduced to the research and it is more apparent how to interpret skin conductance levels in the current research. The following hypothesis and research questions will lead to laying out the methods used in the experimental setup.

2.7. Hypothesis and research questions

As research done by Höök [2000] pointed out is the fact that little research has been done into whether users are satisfied with the changes made to mobile user interfaces. In order to properly track a users' behaviour and present them with the appropriate changes, a highly adaptive user models as seen in section 2.1 has been proven a viable solution for adaptive user interfaces as mentioned by Kühme [1994], since the model documents the users' behaviour and presents adaptations to the user. Nevertheless, Fischer [2000] mentioned that the use of highly adaptive user models is something that is a complicated task to measure. Section 2.2 pointed out principles from a mixed-initiative user interface, combined with adaptive user interfaces can be used when designing for transparency in adaptive mobile user interfaces. The first questions therefore being: Q1: what principles of adaptive user interface types can be used in mobile user interfaces? Section 2.3 concluded with the need for more control over adaptive user interfaces and the need for more transparency of change, in which adaptive support and prompting as mentioned by Kühme [1994] can help to clarify. Therefore the second research question is Q2: how is transparency of change effectively communicated in adaptive mobile user interfaces? In order to clarify the aim on mobile user interface, chapter 2.4 and 2.5 presented guidelines showing that a context of usage and a limited screen real-estate are the key opportunities for adaptive mobile user interfaces. In order to properly evaluate the effect on participants, a user research has to be conducted, preferably in the form of skin-conductance data measurements accompanied with user questionnaires, resulting in the the third question: Q3: what is the effects on a user's (perceived) stress level when (not) communicating transparency of change? The focus in this thesis is to support users in the process of adaptation, as mentioned by Alvarez-Cortes and Zarate-Silva [2007]. The main hypothesis in this thesis is therefore: the amount of transparency of change in a mobile user interface in a mobile application for group work affects the users' (perceived) stress level. Apart from that, Höök [2000] advocates for "*a number of successful IUI (intelligent user interface) applications that together form an equally strong culture as the direct manipulation community.*" Therefore, the additional aim is on attempting to add to the existing body of knowledge on usability research on adaptive mobile user interfaces.

3. Methods

The following section aims to describe the methods of the currents study, starting with the recruitment of participants and followed by the applied user questionnaires; apparatus; experimental procedure; and methods of data analysis.

3.1. Participants and Recruiting

Recruiting participants started with posting an invite to a Facebook-group of which a lot of TUT (Tampere University of Technology) and UTA (University of Tampere) students are a member. Following this invite possible participants were able to fill in a Doodle link to pick a date to participate in the experiment. Possible participants were notified of the fact that a reward in the form of a lunch voucher was applicable. Ten participants responded to the Doodle form, of which later 2 were unable to join the experiments. All experiments were conducted on Monday the 4th of April and Tuesday the 5th of April 2016 in the ESC-lab at the TAUCHI Research Centre of the University of Tampere, Finland. Table 3 displays the background information of the participants.

The eight participants were randomly assigned to either group group 1 (transparent) or group 2 (non-transparent).

Participant	Gender	Age	Group	Prototype
P1	F	24	1 - Transparent	First usage (A) + second usage (B - transparent)
P2	F	29	1 - Transparent	First usage (A) + second usage (B - transparent)
P3	M	25	1 - Transparent	First usage (A) + second usage (B - transparent)
P4	F	20	1 - Transparent	First usage (A) + second usage (B - transparent)
P5	M	25	2 – Non-transparent	First usage (A) + second usage (C – Non- transparent)
P6	F	23	2 – Non-transparent	First usage (A) + second usage (C – Non- transparent)
P7	M	28	2 – Non-transparent	First usage (A) + second usage (C – Non- transparent)
P8	M	26	2 – Non-transparent	First usage (A) + second usage (C – Non- transparent)

Table 3. Participants in the experiment.

3.2. User questionnaires

User questionnaires have been proved to be a suitable method for user research. The following chapters focus on the pre- and post questionnaire that all participants were presented.

3.2.1. Pre-questionnaire

Prior to the actual experiment, participants were asked to fill a short questionnaire to collect some general demographic information (gender, age, profession).

3.2.2. Post-prototype questionnaire

Both after the first usage (A) and second usage scenario (B or C), users were asked to fill in a short questionnaire concerning the prototype. Questions were selected from the User Experience Questionnaire (UEQ) by Schrepp et al. [2009]. Additional questions were added to second usage scenario B (or C consequently)-questionnaire, asking about the 'Layout', 'Creating a group' and 'Changes' page. Additionally, participants were asked how informed and in control they felt during the testing of second usage scenario B (or C). As a conclusion to the second usage scenario B or C, participants were asked how they felt about the experiment as a whole, with the possibility to add an additional comment.

3.3. Apparatus

Prototypes have been proved to be a valuable research method. All scenarios of the Adapt prototype were made using Bohemian Coding Sketch 3 for Mac interface design software, after which the exported .PNG images were made into a clickable prototype using InVision online prototyping tool. The prototypes were presented on an iPhone 4S, which was clamped into a car-kit apparatus and placed on a table (figure 3).

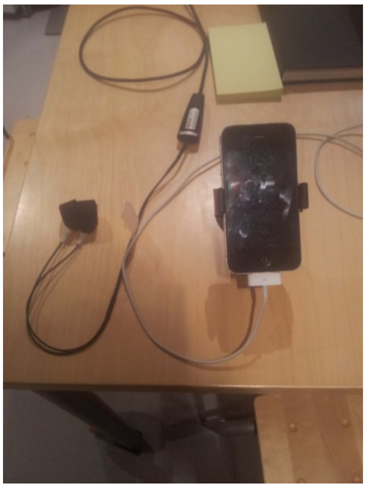


Figure 3. Experimental setup in ESC-lab at the TAUCHI Research Centre.

Skin conductance data was recorded in a single continuous file using the NeXus 10 machine, which was connected to the local laptop in the ESC-lab via Bluetooth. BioTrace+ software was used to monitor and track the output from the SC-data in 32 SPS (samples per second).

3.4. Experimental procedure

The experimental procedure was as follows:

1) The participant was welcomed to the ESC-lab,
2) The participant was asked to fill in a background questionnaire,
3) The participant was introduced to the experiment and the usage/workings of the prototype and SC-sensors,
4) The SC-sensors were attached to the participant's non-dominant hand (middle and index finger, on the intermediate phalanges) and the headphones were put on,
5) The participant was asked to raise their hand when they would start or end any phase of the experiment,
6) 3-minute music listening session (calming instrumental music),
7) The participant was asked to perform the first usage scenario (prototype A),
8) Short questionnaire about the first usage scenario,
9) 3-minute music listening session (calming instrumental music)
10) The participant was asked to perform second usage scenario (prototype B or C),
11) Short questionnaire about the second usage scenario (prototype B or C),
12) Followed by a longer post-questionnaire about differences between the first usage scenario (A) and the second usage scenario (B or C) and the experiment as a whole.
13) SC-sensors and headphones were taken off,
14) The participant was rewarded with a free lunch voucher for the 'Linna' cafeteria on the University of Tampere campus area.

	Group 1 (P1 – P4)	Group 2 (P5 – P8)
Part 1	Baseline exercise (music)	Baseline exercise (music)
Part 2	First usage scenario (prototype A)	First usage scenario (prototype A)
Part 3	Baseline exercise (music)	Baseline exercise (music)
Part 4	Second usage scenario, Prototype B (Transparent)	Second usage scenario, Prototype C (Non-transparent)

Table 4. Experimental design.

Group 1 and group 2 followed the exact procedure from part 1 to 3. In part 1 baseline was achieved by exposing the participant to 3 minutes of music listening as described by Levenson [1988]. During part 2 both groups were exposed to the first usage of the prototype in which they were instructed to perform a few tasks. Part 3 is in place to ensure a proper baseline. Part 4 was different for both groups. In which group 1 was exposed to the transparent scenario as opposed to the non-transparent scenario for group 2.

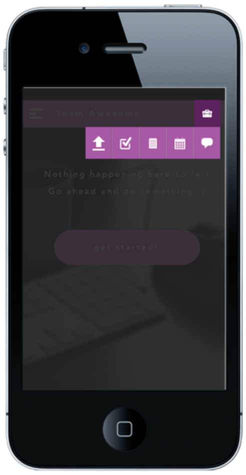
3.4.1. Adapt: a group-work application

The principles of this thesis are tested in the form of a simplified A/B-test prototype in which two versions of a system are compared. One (or more) factors of the prototype are changed from one version to the other. In the case of this thesis this concerns the amount of transparency.

The Adapt mobile application is based on adaptive prompt design principles by Kühme et al. in combination with guidelines by Häkkilä and Mäntyjärvi. Adapt is a prototype of a mobile application used to organise group work. It is focussed on keeping track of activities that are happening on different group tasks. It has the following features: a feed for updates, a list of groups, making new groups and the selection of different tools within a group (chat, calendar, docs, to-do's, content; images, video and URL's). These functionalities are based on surveys done with students from the University of Tampere (more details about this part of can be found in the Appendix).

The functionality of the first usage scenario (prototype A) and the transparent adaptive user interface scenario (prototype B) opposite to the non-transparent adaptive user scenario (prototype C) are explained below and will be linked to earlier stated principles and guidelines as stated in the literature review (Chapter 3). The adaptive support as described by Kühme [1993], is provided in the following situations:

- **Object context**: this concerns the current focus of the user. When for instance creating a new work-group, the user can choose between pre-made groups with certain tools that were frequently used in earlier groups. The tools and preferences that are grouped into the prompt will be the shortcuts in the following new group. As seen in figure 4, which shows the screen the user is shown when he wants to create a new group.



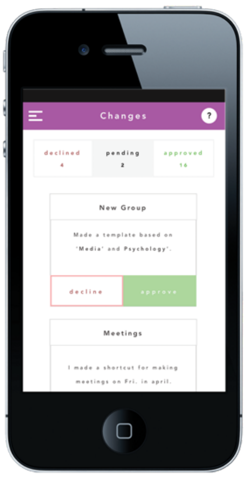
Object context - Tool prompter

Certain tools that are frequently used are clustered into one prompt.

Throughout the usage of the application the tools will change positions or appear/reapear in the tool prompter (based on the usage of them).

Figure 4. Object context (tool prompter) example.

- **Action context**: this concerns pre- and post conditions of the interface. The interface should communicate the change that is about to be initiated. An example of this can be seen in figure 5.



Action context - Adaptive action prompter

Actions that are excecuted by the system are inspectable and editable by the user in the form of a 'Changes'-page that shows pre- and post conditions of the system.

Figure 5. Action context (adaptive action prompter) example.

- **Task context**: this concerns a set of actions that are clustered into the prompt when performing one specific task. As shown below in figure 6.

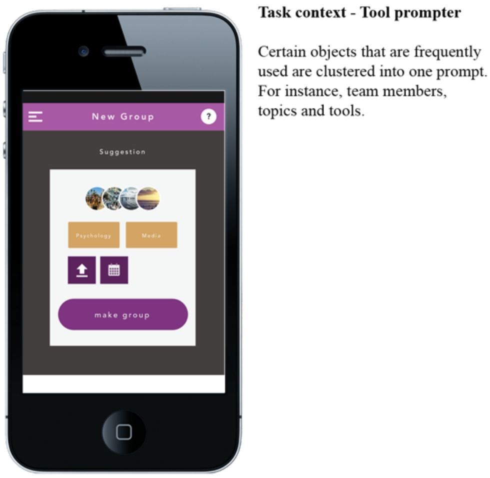


Figure 6. Action context (adaptive action prompter) example.

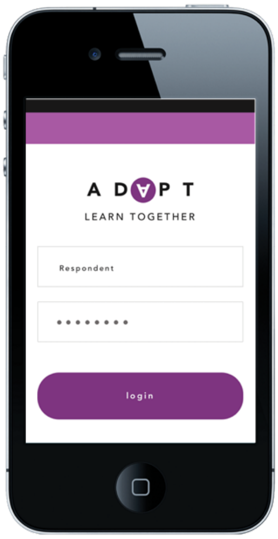
Concluding that the adaptive support is presented in three different contexts. The following chapters (3.4.2, 3.4.3 and 3.4.4) will show three specific scenarios in which different contexts are shown, with different levels of transparency applied to the user interface. While explaining the steps from the prototype, guidelines as presented by Häkkilä and Mäntyjärvi will be used to explain the design choices.

3.4.2. First usage scenario: user interface, shaping the user model

During the first usage scenario (prototype A), participants were asked to perform a certain amount of tasks. During this first usage, the participants would familiarize with the functionalities of the prototype while performing the following steps:

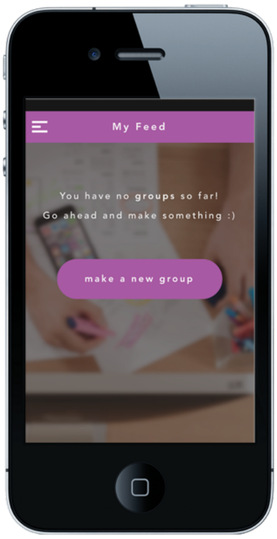
1) Log in to the application
2) Make a new group
3) Upload a picture to the feed
4) Make a new meeting
5) Close the application

During the first step, the participant was asked to log in to the application, from there on the participant was asked to make a new group, as seen in figure 7.



A - Login

The login process to Adapt A.

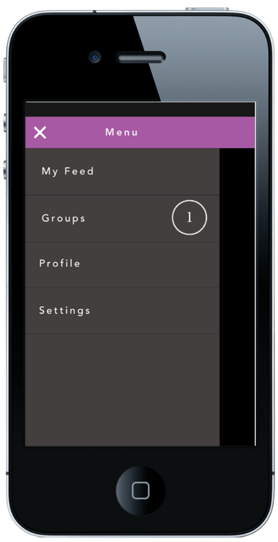


A - Empty feed, new group

The user is able to change name, color, members and topics to match the group' needs.

Figure 7. The login- (left), and empty feed (right) of the first usage scenario (A).

After making a new group, the participant was invited to add content to the group-page feed. This was done by either clicking 'Get started' or one of the options under the 'Toolbox' icon in the top bar, triggering the items seen in annotations 1 to 5 in the screen on the right.

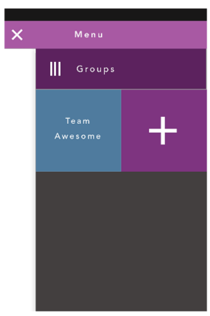


A - Menu

Menu that is triggerd upon tapping the 'hamburger' icon (three horizontal stripes).

1. Menu item for groups

Below: fly-out menu cascading menu on the left.



A - Empty group page

The login screen to Adapt A.

A collection of tools hidden under the 'toolbox' icon.

1. Upload file
2. Task
3. Note
4. Meeting
5. Chat

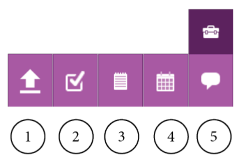


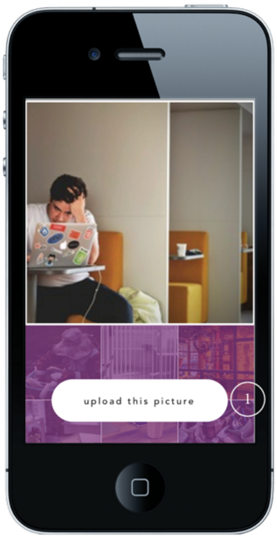
Figure 8. Menu (left) and Empty group page (right) of the first usage scenario (A).

After making a new group the participant was asked to upload a new picture to the feed.

A - Upload picture 1

The user can upload a picture.

1. Possible picture (every picture)



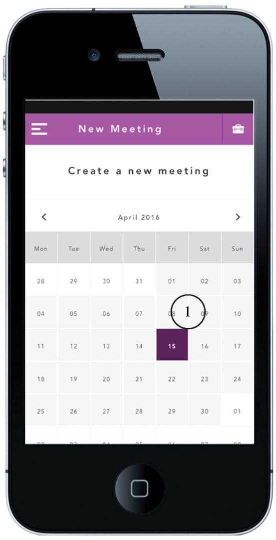
A - Upload picture 2

Menu that is triggerd upon tapping the 'hamburger' icon (three horizontal stripes).

1. Button to upload picture to the team page feed.

Figure 9. Upload picture page (left), and detail Upload picture (right) of the first usage scenario (A).

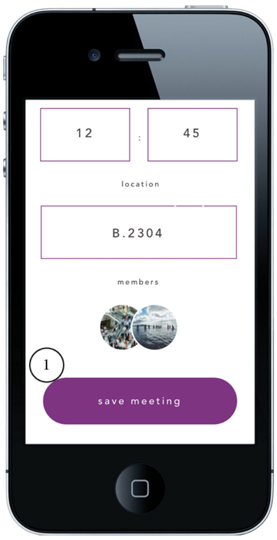
When the picture was uploaded, the participant was asked to plan a new meeting, going back to the toolbar icon and selecting the calendar icon. After a suitable date was picked, the meeting was saved to the calendar.



A - New meeting 1

The user can plan a new meeting.

1. Possible dates for a new meeting. (in the scenario, the user picked 15 April).



A - New meeting 2

The user can book a meeting room and add team members to the converstation, afterwards the event is saved clicking the 'Save meeting' button.

1. Save meeting button

Figure 10. New meeting page, and detail New meeting of the first usage scenario (A).

After performing these couple of steps, the participant was lead back to the group page and was asked to close the application. Concluding this short scenario, the participant was asked to fill in a short questionnaire.

3.4.3. Second usage scenario: Transparent adaptive user interface (B)

During the second usage of the application 4 out of 8 participants were asked to perform a certain amount of tasks using prototype B. During this second usage, the participant was asked to perform the following steps:

1) Log in to the application
2) Go to the group-page of 'Team Awesome'
3) Make a new meeting
4) Make a new group
5) Find a page where all 'Changes' are shown
6) Approving of one change that is made
7) Close the application

Throughout this scenario, the participant was asked to look for additional information about the page they were looking at. This information was communicated in the form of question mark icons in the top navigation bar of the user interface, as seen in the figure 11 below. This feature of the prototype answers to *GL1: Consider the uncertainty in decision-making situations* and *GL4: Avoid information overflow* as proposed by Häkkilä and Mäntyjärvi [2006]. In which the user can be informed/notified of changes that are made whenever they wish to do so. The following images will show the flow of usage in the testing scenario of prototype B.

The first step was to login to the feed and open up the menu and detect changes, in the following screens an addition to the menu list is shown. Previously invisible list-items 'Changes' and 'Calendar' are now shown (since the user model has tracked the usage of these options) as seen in figure 11. This feature of the prototype answers to *GL3: Personalisation* and *GL6: remember mobility* as proposed by Häkkilä and Mäntyjärvi [2006], because the user is faced with a personalised feature that is added to the user interface. Also, the options can be hidden under the Toolbox icon due to limited screen real estate.

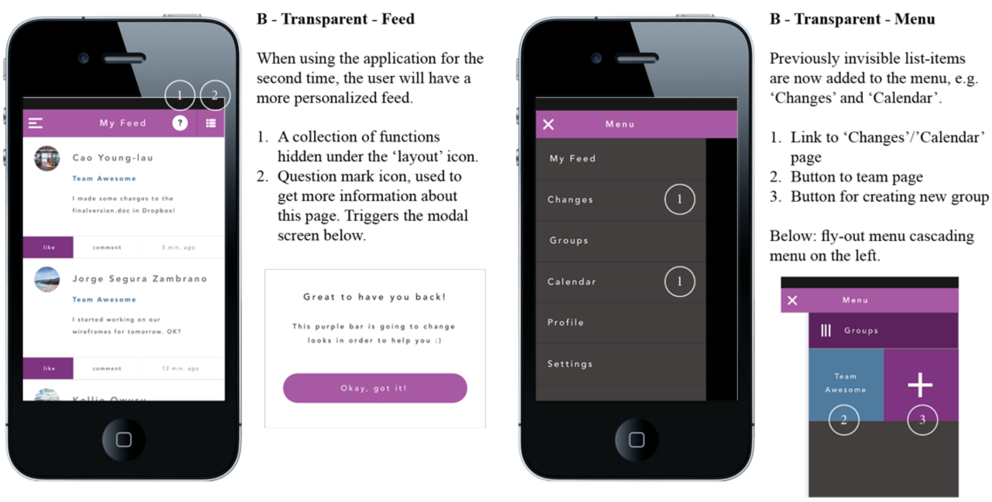


Figure 11. Feed page (left) and menu (right) of the second usage scenario (B).

In figure 11 the team page (left) and the option to plan a new meeting (right) are shown. The participant was asked to go the page of 'Team Awesome' and plan a new meeting, based on behaviour from prototype A. The new meeting data was suggested to the participant (e.g. one week from the previous meeting). The participant was also able to plan a new meeting based on any other date on the calendar. This feature of the prototype answers to *GL2: personalisation* and *GL7: secure the user control*, as proposed by Häkkilä and Mäntyjärvi [2006], because the user is able to ignore the clustered options that are made in the tool prompt and make a new meeting based on new data.

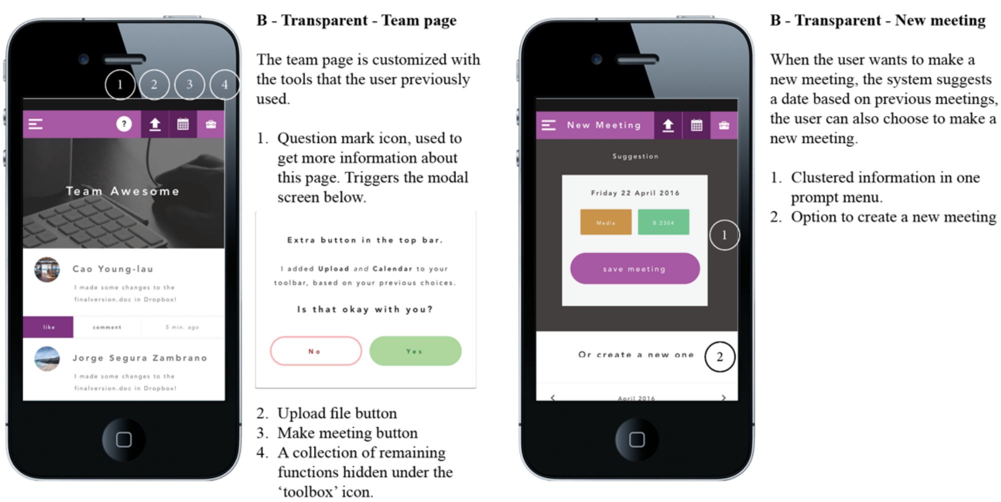


Figure 12. Team page (left) and New meeting (right) of the second usage (B).

After planning the meeting, the participant was asked to form a new group. Again the system gave transparent information about the changes, placed in the prompt menu when the participant pressed the 'Question mark' icon. The preferences for a possible new group were clustered into one adaptive tool prompt. This feature of the prototype answers to *GL9: visibility of system status*, as proposed by Häkkilä and Mäntyjärvi [2006], due to the prompt that explains that relationships between tools, members and topics and forms them into a possible new group.

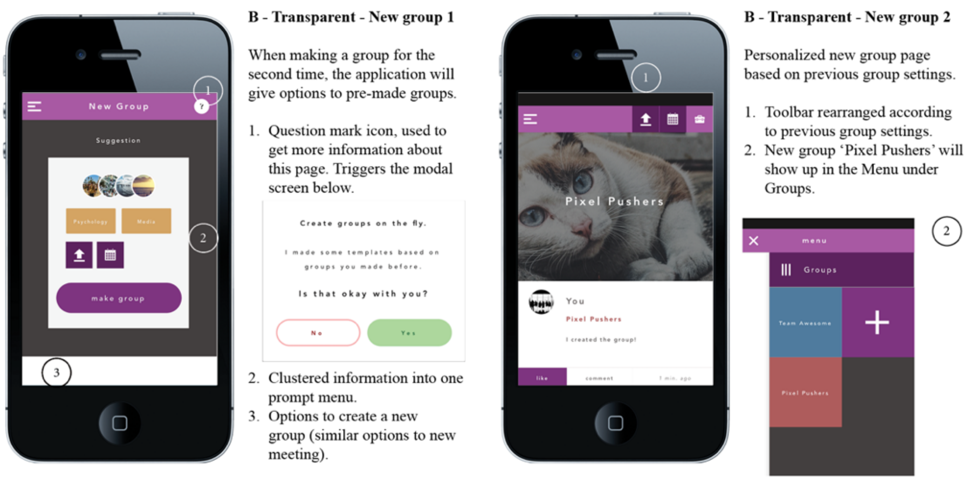


Figure 13. Prompt of a new group (left) and the group page (right) of the second usage scenario (B).

After creating the new feed, the participant was asked to toggle off all the post to one particular group. This feature of the prototype answers to *GL3: personalisation, GL4: avoid information overflow* and *GL7: secure the user control*. [Häkkilä and Mäntyjärvi, 2006].

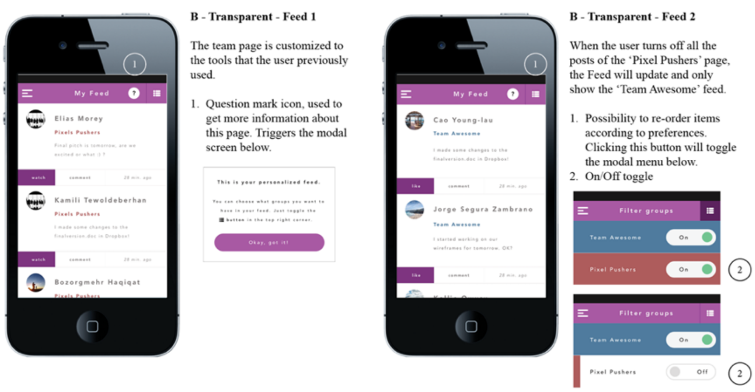


Figure 14. Feed page (left) and the toggle function (right) of the second usage scenario (B).

Before ending the second scenario, the participant was asked to look for a place to find all of the changes that were made during the second usage of the application, this was found under the menu-list item ‘Changes’ as seen in figure 15. This feature of the prototype answers to *GL1: Consider the uncertainty in decision-making situations*, *GL3: personalisation*, *GL4: avoid information overflow, GL9: visibility of system status* and *GL10: usefulness,* as proposed by Häkkilä and Mäntyjärvi [2006]. All due the fact that the user can be informed/notified of changes that are made. Also the ability to look ‘inside’ of the changes that are made, as mentioned by Höök [2000], when she talks of an ‘*inspectable’* system.

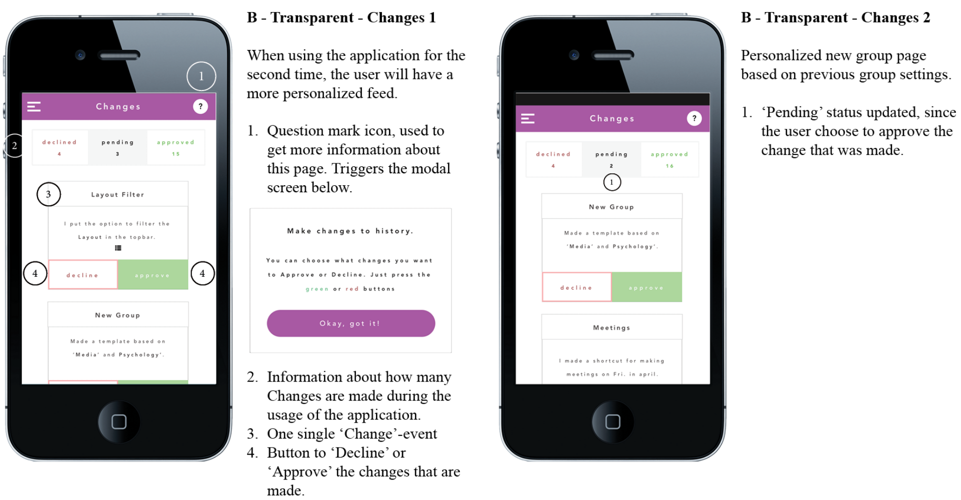


Figure 15. Changes page (left) and the changes page (right) after approving one of the changes of the second usage scenario (B).

In addition to above-mentioned menu, a possible implementation of transparency of change in the menu design of the Adapt application can be found in the fact that the items will change in colour or re-order themselves, as seen in figure 16 below.

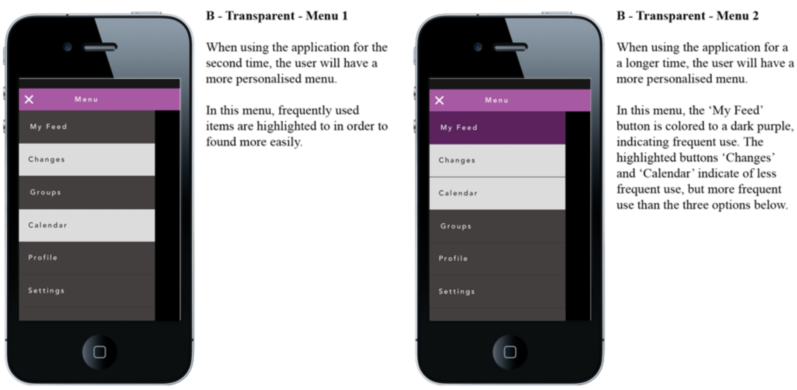


Figure 16. Menu design of the second usage scenario (B).

3.4.4. Prototype C: Non-transparent adaptive user interface

In this second scenario the 4 other participants were asked the same actions as the other 4 participants that got to use prototype B (transparent) during the second usage. Most apparent differences in prototype C (in relation to prototype B) is the lack of transparency of change in any of the changes that were executed by the system. Differences derived from the lack of transparency are explained below. In any screen in prototype C, the user is not able to get additional information about the current system status in order to clarify the changes that are made to the system.

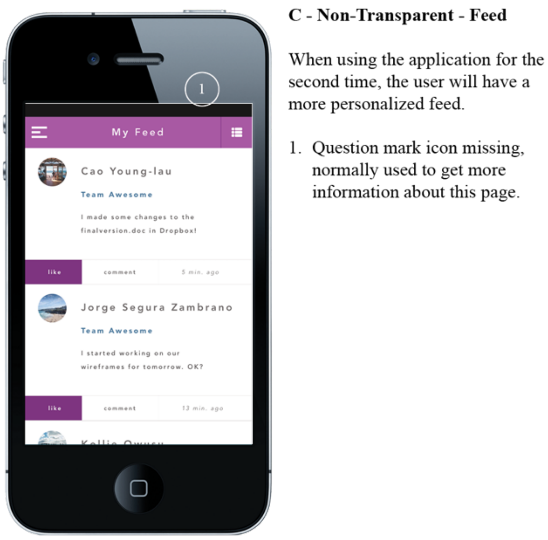


Figure 17. The feed of the second usage scenario (C), the user is unable to get any additional information.

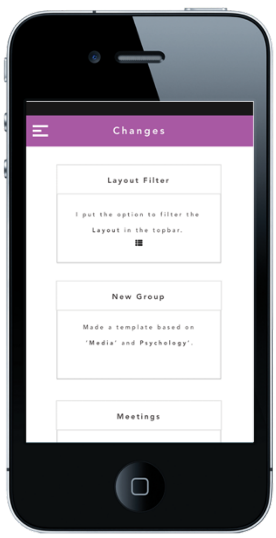
When making a new group in prototype C, the user was limited to pre-made options made by the system, based on previous usage by the user. This is seen in figure 18 below.

C - Non-Transparent - Groups

When making a new group, the user is limited to only the clustered prompt options learned by the system.

Figure 18. Making a new group in the second usage scenario (C).

An important part to the transparent adaptive prototype (B) is missing in prototype C, the ability to get a look into the system, but also to alter its behaviour. This behaviour is seen in figure 19, whereas the user can not alter system-initiated changes.



C - Non-Transparent - Changes

Changes to the pages are inspectable, but there is no option to re-do them.

Figure 19. Making a new group in the second usage scenario (C).

3.5. Data analysis

Data analysis was done from the following dependent variables: 1) a participants' perceived pleasantness (user questionnaire), and 2) an objective view on the perceived stress level (skin conductance data). The independent variables to this experiment was the amount of transparency in second usage B and C. Noting that the participants were unaware of the existence of a third prototype, to ensure objectivity in regards to their acts or answers. In order to state a clear distinction between the prototypes throughout this section. Prototypes will be called first usage (A) and second usage transparent (B) and second usage non-transparent (C).

First, the subjective data from the user questionnaires was collected. This data was written down in a spreadsheet from which mean values to each question could be calculated. The additional comments were also reported and will be used to support the objective skin conductance data. Variables in this part of the data-analysis were the overall experience of the prototype as perceived by the user, in the following categories: understandable, complicated, pleasant, clear, easy to learn and overall feeling during the testing. With this data, a second independent sample t-test was done between data from group 1 (transparent) and 2 (non-transparent).

After this analysis, data-analysis of the skin conductance data was done. First, the mean factor of the following four skin conductance data sessions was calculated: baseline 1, testing first usage scenario (A), baseline 2, testing second usage scenario (B or C). After this, the results from the testing session could be subtracted from the baseline value, resulting in the mean of one particular session. With this data, another independent sample t-test was conducted.

4. Results

In the following section the results of the skin conductance data and the user experience questionnaire will be given.

4.1. Skin conductance

An independent samples t-test was conducted in order to compare the amount of perceived stress in a transparent and non-transparent mobile application. The skin conductance levels did not differ significantly between group 1 and group 2 during the first usage $MD = 1.43$, $df = 6$, $t = 2.014$, $p = .087$. The difference between these groups was non-significant during the second usage as well ($MD = 2.65$, $df = 6$, $t = 2.003$, $p = .092$. However, figure 20 suggest that, although not statistically significantly, the group 1 experienced somewhat more stress during both first and second usage as compared to the group 2.

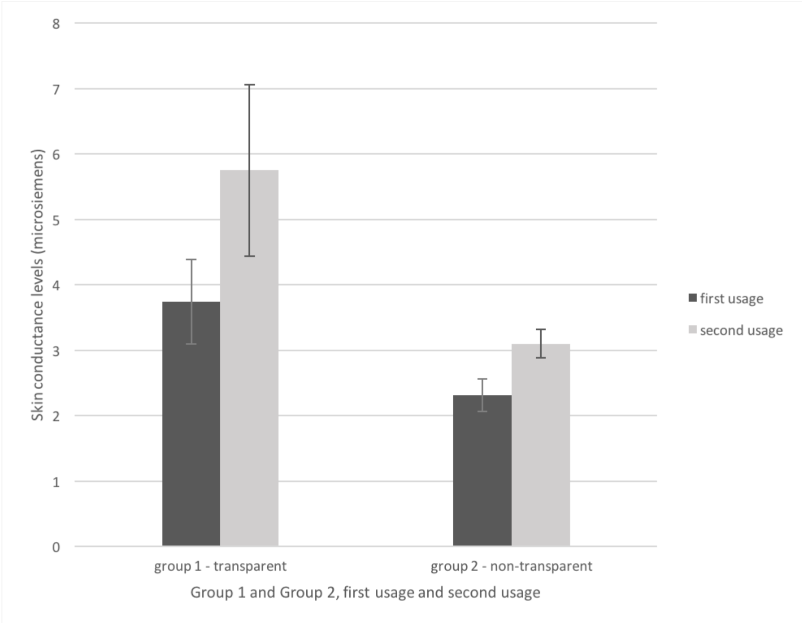


Figure 20. Mean baseline-corrected SCL results of GR1 and GR2 during first usage and second usage, in which error bars represent standard errors of the means.

4.2. Subjective evaluation

During both the subjective evaluation of the first usage scenario (A) and second usage scenario (B or C) the participants were asked to answer questions about the prototype being: understandable, complicated, pleasant, clear, easy to learn and overall feeling during the testing. These scales were derived from the User Experience Questionnaire (UEQ). The following paragraphs describe the results of the subjective evaluation for each prototype.

4.2.1. Evaluating first usage: prototype A

In the following chart the means of these variables are given. Figure 21 shows mean rating for the rating scales using pooled data of group 1 and group 2.

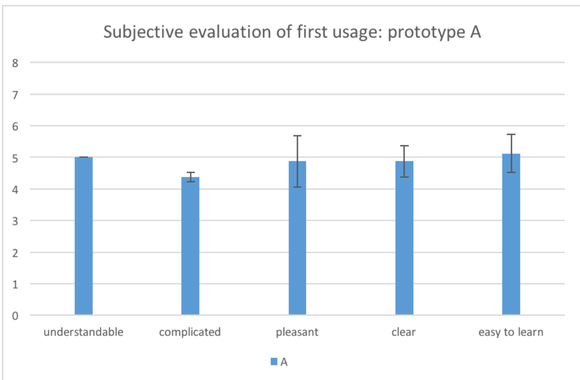


Figure 21. GR1 and GR2 subjective evaluation of the first usage (prototype A).

Understandable

All participants thought prototype A was very understandable, some participants expressing the fact that they see the need of this application its functionalities.

Complicated

All participants thought prototype A was above average complicated. Participants expressed that this was also due to the fact that this was their first time using the application and felt some instructions prior to the experiment to be incomplete. In addition to that, there was some lack of feedback in the user interface and issues with understanding the meaning of certain icons in the user interface (e.g. calendar).

Pleasant

All participants thought prototype A was above average pleasant. Participants expressed that the overall look and feel of the application felt modern and very usable.

Clear

All participants thought prototype A was above average clear. No major complications came about when testing the prototype for the first time.

Easy to learn

All participants thought prototype A was very easy to learn. The participants made clear that all functionalities used in the application felt familiar since they had seen them in other application (e.g. making groups and appointments, interacting with a main feed).

4.2.2. Evaluating second usage: prototype B and C

In figure 22 the subjective evaluation means of prototype B and C can be seen.

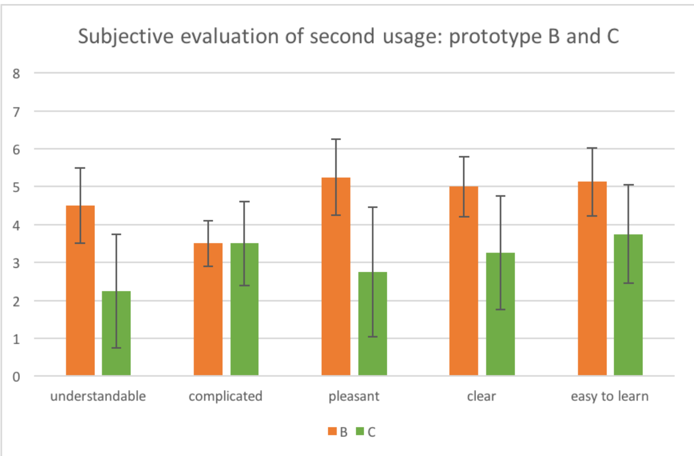


Figure 22. GR1 (prototype B - transparent) in orange and GR2 (prototype C - non-transparent) in green; evaluation of the second usage.

Evaluating second usage prototype based

Understandable

Participants in GR1 (prototype B – Transparent) thought the application was more understandable during the second usage.

Complicated

Participants in GR1 (prototype B – Transparent) thought prototype B was not complicated. They thought the application was not complicated since they had seen its dynamic in the first usage (A). Participants in GR2 (prototype C - non-transparent) thought prototype C was more complicated. Participants in GR2 (prototype C - non-transparent) expressed it was hard to make a meeting/group based on other input then the one that was suggested, they would like to have seen more options here.

Pleasant

Participants in GR1 (prototype B – Transparent) thought prototype B was very pleasant. Participants liked the fact that the application had saved their preferences. Participants in GR2 (prototype C - non-transparent) thought prototype C was not very pleasant. Some participants said they ‘lost track’ at some point of what to do, and felt like they were no longer in control of what they were doing.

Clear

Participants in GR1 (prototype B – Transparent) thought prototype B was very clear. Participants pointed out that this was due to the fact that there was extra information available concerning changes to the user interface. Participants in GR2 (prototype C - non-transparent) prototype C was not very clear. Participants again expressed that the guided process felt ‘awkward’ to them.

Easy to learn

Participants GR1 (prototype B – Transparent) thought prototype B was very easy to learn. Participants thought the use of the application was not complicated. Participants in GR2 (prototype C - non-transparent) thought prototype C was not easy to learn. Participants in GR2 (prototype C - non-transparent) thought the application was as easy to learn as the other, but due to the fact that there was no proper guidance in place.

Comparing mean differences subjective evaluation prototype B and C

After calculating the mean differences of the evaluation from prototype B and C (as stated in 4.2.2) these came out as significant with p=0.01 and a t-value of 3.76. Meaning that prototype B was perceived as being more understandable, less complicated, more pleasant, more clear and easy to learn as opposed to prototype C during the second usage.

In addition to the above stated questions (‘understandable’ to ‘overall feeling’) participants were asked some additional question about features that were specifically designed for prototype B (transparent) and C (non-transparent). These questions concerned the following functionalities: reordering the layout of the main feed, pre-made options for creating a group/planning a meeting, 'changes' page, informed about changes and the feeling of being in control throughout the scenario. The findings concerning these questions will be displayed in the following paragraph.

4.2.3. Evaluating additional features of prototype B and prototype C

All participants were given the following questions about the additional features after testing of prototype B and C. Results to these questions can be seen further on in figure 23.

1) How did you feel about the '*Layout'* option to re-order your feed in prototype B?
2) How did you feel about the pre-made options for '*Creating a group*' and '*Plan a meeting'*?
3) How did you feel about the '*Changes'* page to decline or approve changes made to your application?
4) How well were you informed about changes in the user interface in prototype B/C?
5) Did you feel in control during prototype B/C?
6) Overall feeling during prototype testing?

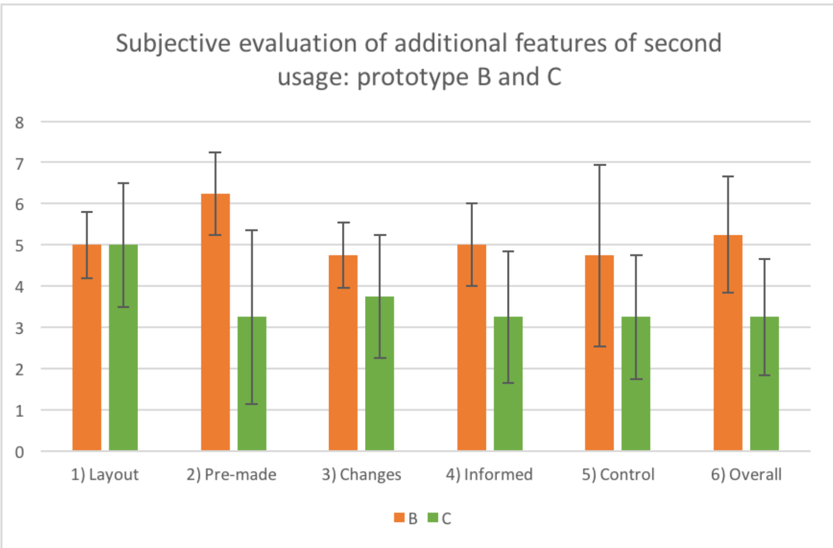


Figure 23. GR1 (prototype B - transparent) in orange and GR2 (prototype C - non-transparent) in green; evaluation of additional features.

Additional: reordering layout
GR1 (prototype B - transparent) and GR2 (prototype C - non-transparent) thought reordering the layout was a good feature to the application.
Additional: pre-made options
GR2 (prototype C - non-transparent) expressed the need to make their own groups as well, which was missing in the opinion. Meaning GR2 (prototype C - non-transparent) thought reordering the layout was a good feature to the application, if only it was more editable.
Additional: changes
GR1 (prototype B - transparent) thought the 'Changes' page was a good feature to the application. Although GR1 (prototype B - transparent) expressed the fact that they were unfamiliar with the term 'Changes' but did try out the function and saw its potential. GR2 (prototype C - non-transparent) expressed they saw 'Changes' merely as a page to see their history (similar to an internet browser).
Additional: informed about changes
GR1 (prototype B - transparent) was well informed about the changes that were made to the application. Some participants of GR1 (prototype B - transparent) expressed the need to see changes applied to individual groups, instead of all the group feeds. GR2 (prototype C - non-transparent) expressed they felt lost at some point during the usage of the application.

5. Discussion

The SC-level presented a higher mean of GR1 (prototype B - transparent) as opposed to GR2 (prototype C - non-transparent). Although, the difference was not quite statistically significant (i.e., p-values approached significance), the trend can be clearly seen in figure 20. From this the conclusion can be drawn that stress levels were higher during the transparent scenario of prototype B then during usage of the non-transparent prototype C. This goes against the predefined hypothesis which entails that the scenario with a higher level of transparency would cause for lower stress levels. However, no significance results could be find between the different group outcomes. This was probably due to the small number of participants, namely eight participants.

The fact that GR1 (prototype B - transparent) experienced a higher stress level could be due to the experiment setup. Participants explained that steps in the scenario were somewhat unclear. Besides, the standard deviation in GR1 (prototype B - transparent) was fairly high (SD=2.61) caused by one participant having a higher baseline SC-level then the others causing the mean to differ greatly. However, stress levels of the other participants in GR1 (prototype B - transparent) were still higher then those in group 2 (C-non-transparent). Looking at the questionnaires from group 1 it showed that participants expressed the user interface being unclear regarding some points, such as certain icons and flow of the application. This is supported by Höök's [2000] research stating that users can perceive these prompts as interruptions, even when attempting to be fully transparent and just in place as guidance. These issues were not expressed by GR2 (prototype C - non-transparent), since there was no transparent guidance in place.

On the other hand; the subjective data showed that the attractiveness and pragmatic usage (derived from the simplified User Experience Questionnaire) of prototype B (transparent) was perceived to be better then the prototype C (non-transparent). This is in accordance to conclusions drawn by Kay [1994] that mixed-initiative systems that enable a user to 'peek' into the system's dynamics are a preferable technique when designing adaptive user interfaces. Participants expressed an overall feeling of acceptance towards functionalities such as re-ordering the layout, having pre-made choices based on their previous actions and the possibility to change the alterations back to its original state in the form of a 'history' function. This conclusion is also supported by Kozierok and Maes [1993], who state that splitting the interface in one predictable/editable part, and one part that is adapting in the background and is not editable, is seen as a more ideal situation.

The hypothesis stated that once a prototype has a more fulfilling user experience a participant's stress level had to be lower. This proved not to be the case in this research. It remains unclear if these results are due to the fact that the prototypes differed in transparency of change, or if the complexity of the prototype and accompanied scenario caused an increase in stress. The phenomenon of adaptive support was also a point of concern by Alvarez-Cortes and Zarate [2007], who expressed the fact that prompts can interrupt a user's flow with the system. Knowing if this was the case would help explaining these differences and the forthcoming unconfirmed hypothesis. Future research will therefore be needed in which a fully working prototype in the form of a mixed-initiative prototype with a working highly adaptive user model as a basis, needs to be tested. Skin conductance was proven to be a reliable source of physiological input, nevertheless a larger user group will benefit the data greatly. Apart from that, as Kühme [1994] mentioned: "*it takes time for a user to feel comfortable with a fully adaptive system and the artefacts that come with it*". Therefore, future research is needed in order to expose participants to more adaptive mobile user interfaces and measure their reactions to them.

5.1. Limitations

Evaluating a prototype as the Adapt prototype described in this thesis would be more reliable if actual usage is recorded over a longer period of time. The fact that the number of participants was limited played parts in concluding a non-significant conclusions of the hypothesis. Furthermore, the fully controlled lab-setting could have influenced the results in multiple ways. Participants expressed feelings of distress when performing a predefined scenario. This could interfere with a user's perception of the applications and its intended flow of use.

5.2. Future research and implementations

Future mobile adaptive applications that are adaptive of nature can rely on the guidelines and principles as described in this thesis. Participants expressed great satisfaction over the fact that the application 'learned' and that changes were editable by themselves. Hence concluding that a fully adaptive interactive system (with a user interface) with no user interference is still a step away from being developed. Taken into account that a more fully adaptive user model will be in place to control a participant's choices in order to create a more personalized system, instead of having a predefined scenario in place.

6. Conclusions

During this thesis the main goal was to determine if the amount of transparency in an adaptive mobile user interface influenced the (perceived) stress levels in participants. Apart from that, implementing adaptive user interface principles originally designed for desktop interfaces to mobile applications was a fairly novel field of research as well. In order for users to be more accepting for changes that were made to the interface, the interface had to communicate the changes that were made. The means by which a user interface communicates these changes is expressed in 'transparency of change'. These levels of transparency are visualized in two different prototypes. One prototype was transparent in its changes (B), the other one was not (C). The main hypothesis in this thesis therefore was: The amount of transparency of change in a mobile user interface in a mobile application for group work affects the users' (perceived) stress level. Findings from this statement can be described in the following paragraphs.

Principles of adaptive user interface for desktop application such as the adaptive support and prompting by Kühme [1993] and the glass box-model by Höök [1996] are promising techniques that can be applied to mobile user interface design just as well. Guidelines described by Häkkilä and Mäntyjärvi [2006], in particular those concerning uncertainty in decision making, personalisation and avoiding information overflow (due to a mobile context and limited screen real estate) are guidelines to take into account when designing adaptive mobile user interfaces. Conclusions from these guidelines combined with results from questionnaires is that visibility of system status and securing the user control are of great importance.

When communication changes in the user interface, transparency of change is of importance. Certain design principles derived from these techniques were used to construct the Adapt prototype: such as the ability to re-order the layout, have a look at the the history of 'changes' and having certain tools clustered in prompted in certain situations. All these functionalities are in place to ensure visibility of system status and sustaining the users control. Testing these differences resulted in testing a first prototype to track the ‘first usage’ (A), followed by a second usage scenario (B or C) in which the user was presented a ‘transparent’ (B) or ‘non-transparent’ (C) prototype.

In order to measure these feelings of stress skin conductance data was proven to be a qualified method of research. A lower skin conductance response to certain events would prove a lower stress level during the testing scenario. Nevertheless, results showed different outcomes as opposed to the predefined hypothesised results. This might have been caused by parameters outside of the research ‘focus. On the other hand, subjective data in the form of user questionnaires proved that participants valued the transparent adaptive user interface highly, with the ability to alter certain changes that were made. Resulting in the fact that a mixed-initiative user interface is valued more than a fully adaptive user interface that provides no feedback or alteration methods whatsoever.

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Appendix

Defining functionalities

In order to test multiple principles derived from earlier research, there was a need for a novel application. Since all of the participants are students at the University of Tampere, the majority of the students are familiar with some sort of group work. The ideal test case for this thesis therefore resides in an application used to support group work. The functionalities in this 'group work' or 'collaborative work' application come forth after a preliminary survey about group work and certain tools students use during that work. A total of 13 participants was surveyed through the Typeform-survey leaving the following 'tasks and files' as result.

Tasks and files: This survey showed that students have to perform following main tasks the most: brainstorming (85%), chatting/discussing (69%), planning (69%), initiating ideas (54%) and writing reports (54%). As far as functionalities concerned, they answered as follows: shared/collaborative document (92%), calendar (54%), chats (54%), to-do lists (54%), email (15%). They were also asked what kind of applications they used the most, being: Google Docs (100%), e-mail (54%), Facebook groups (38%), Facebook chaat (31%), mobile chat (31%). Concerning file-sharing, the following results came up: text files (92%), Images/videos (85%), presentations (77%), school reports (54%), URL's (46%).

Mobile usage: 69% of participants claimed to be using their mobile phone for group work. They used for the following tasks: planning (69%), chatting (62%), email (42%), notifying group members (46%), planning a place to work at (38%).

Appendix - Use case scenarios 1/4

Hello!

Thank you for making it to my prototype testing session. Please, sit back and relax. Please follow the steps as described below.

Introduction

In the following test you will be using a group-work application. It can be used to form groups, schedule appointments, share pictures and other nifty handiwork for students.

You will be asked to perform certain tasks. In the first scenario called 'Adapt 1a' you will use the application for the first time, imagine you are using the application for the second time in scenario 'Adapt 1b'.

1. Please fill in **Part** 1of the questionnaire on the laptop (stop after 4)
2. Now I will help you to put on the skin conductance sensors.
3. Please put on the headphones, I will start the track for you
4. Once the track is finished, you can take the headphones off, raise your hand and continue with the following steps:
5. Open the application called 'Adapt 1a' on the mobile device in front of you

Appendix - Use case scenarios 2/4

Adapt 1a

When you opened ‘Adapt 1a’, you are kindly asked to do the following:

6. Raise your hand if you’re going to start
7. Press the login button
8. Try to create a new group
9. Change the following things:
    a. Name the group
    b. Pick the second colour
    c. Add a member
    d. Add topics
    e. Create group
10. ‘Get started’ with the new group
11. Upload a new picture to the group
12. Make a new meeting on 15 April at 12:45, in room B.2304
13. Save the meeting
14. You are back at the ‘Team Awesome’ page
15. You can close the application now
16. Once you’re done with Adapt 1a, raise your hand
17. You can continue with the questionnaire on the laptop
18. Once you’re done with this part of the questionnaire, please put on the headphones. I will start the track for you.
19. If you’re done with this step, please raise your hand and continue with Adapt 1b afterwards on the next page.

The other instructions are on the following page.

Appendix - Use case scenarios 3/4

Adapt 1b

Adapt 1b is the same application as Adapt 1a, but opened for the second time.

1. Raise your hand if you're going to start
2. Open the application called '**Adapt 1b**'
1. Press the login button
2. Scroll through the feed
3. Where would you tap if you needed more information about this page? Tap this place, and read the information
4. Go to the group page of 'Team Awesome'
5. Where would you tap if you needed more information about this page? Tap this place, and read the information
6. Plan a new meeting
7. You are back at the page of 'Team Awesome'
8. Try to make a new group
9. Where would you tap if you needed more information about this form? Tap this place, and read the information
10. Finish making the new group
11. You are on the new page of 'Pixel Pushers'
12. Go back to 'My Feed'
13. Where would you tap if you needed more information about this page? Tap this place, and read the information
14. Try to hide all posts from 'Pixel Pushers'
15. Where would you go to see all Changes?
16. Where would you tap if you needed more information about this page? Tap this place, and read the information
17. Try to 'Approve' the first post
18. Go back to My Feed
19. If you're done with this step, please raise your hand and continue with the questionnaire on the laptop.

Please continue with the questionnaire on the laptop by clicking 'Continue'

Appendix - Use case scenarios 4/4

Note: *participants were given prototype B in this case, but were actually presented with the non-transparent prototype C. To not influence their opinion this prototype was called B, instead C (suggesting there were three prototypes).*

Adapt 1b

Adapt 1b is the same application as Adapt 1a, but opened for the second time.

3. Open the application called ‘**Adapt 1b’**’
4. Login to the application
5. Scroll through the feed
6. Go to the group page of ‘Team Awesome’
7. Try to plan a new meeting
8. You are back at the page of ‘Team Awesome’
9. Try to make a new group
10. Finish making the new group
11. You are on the new page of ‘Pixel Pushers’
12. Go back to ‘My Feed’
13. Try to hide all posts from ‘Pixel Pushers’
14. Try to find a place to see all changes
15. Go back to My Feed
16. If you’re done with this step, please raise your hand and continue afterwards.

Please continue with the questionnaire on the laptop.

Appendix - Background Questionnaire

Participant ______________
(*to be filled in by the researcher)*

Please encircle your desired answer.

1) Gender Female Male

2) Age ______________

3) How would you describe your computer skills?

Bad ----------------------------------Normal---------------------------------- Good

1 2 3 4 5 6 7

Post Experiment Questionnaire – First usage – Prototype A

Participant ______________

(*to be filled in by the researcher)*

On a scale from 1 to 7, how would you rate the user interface in this first scenario?

Not understandable ----------------------Neutral----------------------- Very Understandable

1 2 3 4 5 6 7

Complicated ------------------------------Neutral----------------------------- Not Complicated

1 2 3 4 5 6 7

Unpleasant -------------------------------Neutral-------------------------------- Pleasant

1 2 3 4 5 6 7

Unclear ------------------------------------Neutral--------------------------------- Clear

1 2 3 4 5 6 7

Not easy -----------------------------------Neutral--------------------------------- Easy

1 2 3 4 5 6 7

Additional comments?

____

____

Post Experiment Questionnaire - Second usage - Prototype B/C

Participant ______________
(*to be filled in by the researcher)*

On a scale from 1 to 7, how would you rate the user interface in this second scenario?

Not understandable ---------------------Neutral---------------------- Very Understandable

1 2 3 4 5 6 7

Complicated -----------------------------Neutral----------------------------- Not Complicated

1 2 3 4 5 6 7

Unpleasant -------------------------------Neutral------------------------------- Pleasant

1 2 3 4 5 6 7

Unclear -----------------------------------Neutral--------------------------------- Clear

1 2 3 4 5 6 7

Not easy ----------------------------------Neutral--------------------------------------- Easy

1 2 3 4 5 6 7

How did you feel about the 'Layout' option to re-order your timeline?

Not helpful ------------------------------Neutral--------------------------------- Helpful

1 2 3 4 5 6 7

How did you feel about the shortcuts to 'Creating a group' and 'Plan a meeting'?

Not helpful ------------------------------Neutral--------------------------------- Helpful

1 2 3 4 5 6 7

How did you feel about the 'History' option to adjust changes?

Not helpful ------------------------------Neutral--------------------------------- Helpful

1 2 3 4 5 6 7

How well were these changes communicated by the interface?

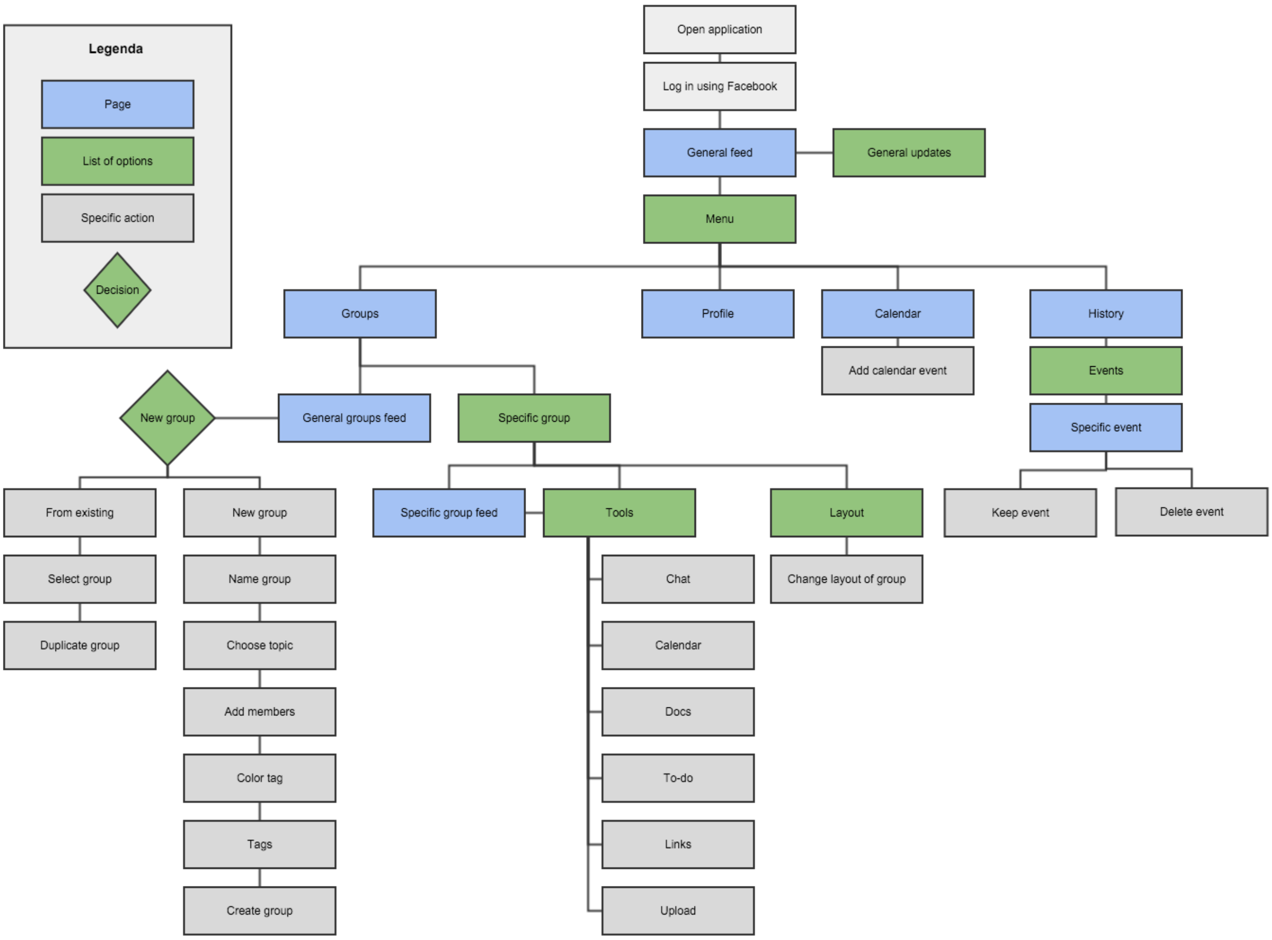
Not clear ----------------------------------Neutral----------------------------------- very clear

1 2 3 4 5 6 7

Additional comments?

Thank you for participating!

Appendix – Flowchart Adapt application



Appendix – Flowchart Adapt application second usage